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Effect of Government Data Openness on a Knowledge-Based Economy

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Abstract

Many governments have recently begun to adopt the concept of open innovation. However, studies on the openness of government data and its effect on the global competitiveness have not received much attention. Therefore, this study aims to investigate the effects of government data openness on a knowledge-based economy at the government level. The proposed model was analyzed using secondary data collected from three different reports. The findings indicate that government data openness positively affects the formation of knowledge bases in a country and that the level of knowledge base of a country positively affects the global competitiveness of a country.

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Keywords: Open data; Open government; Data openness; Knowledge-based economy; Endogenous growth theory; Global competitiveness

1. Introduction

Open innovation denotes the paradigm shift of firms and governments from closed to open [5]. This paradigm shift is characterized by the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for the external use of innovation. In this study, innovation, which is defined as something original and more effective, is viewed as the application of better solutions that meet new requirements or existing market needs. This application is achieved through more effective products, services, processes, and technologies that are readily available to markets, governments and society [28]. Therefore, to perform innovation successfully, abilities to acquire knowledge, to create new knowledge, and to diffuse this knowledge to others are important [28]. The capability of knowledge-based innovation at the

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government level ultimately enhances the level of the knowledge-based economy, which acts as a driving force to improve the competitiveness of a country [7].

Recently, many governments have started to adopt the concept of open innovation, what is also called, open government. It is a type of governance in which the citizens have the right to access the documents or data of the government to enable effective public oversight. In fact, the number of open data sites in the government level increased from 77 countries in 2013 to 86 countries in 2014 [9-10]. The first objective of government data openness is to improve the reliability of the government from the political perspective by increasing transparency of the government and to create new employment and business opportunities from the economic perspective by having more participation and collaboration with the private sector [26]. The second objective is to strengthen the global competitiveness of the government through economic innovation [26]. As government data openness is expected to have a positive effect on the national economy, global countries are pursuing the open data policy. However, studies on government data openness and its effect on the global competitiveness of the government have not received much attention until now.

To fill the research gap, this study attempts to investigate the effects of government data openness on the knowledge-based economy at the government level. Specifically, this study explores the following research questions:

- *How does government data openness affect the formation of a country's knowledge base?*
- *How does the level of knowledge base of a country affect its global competitiveness?*

2. Literature Review

2.1. Open data as a foundation of the knowledge-based innovation (economy) in a country

Open data is defined as "data that can be freely used, re-used and redistributed by anyone – subject only, at most, to the requirement to attribute and share alike" [26, p.6]. Open government data denote the "data and information produced or commissioned by government or government-controlled entities that are opened up for use and reuse by public and private agents alike" [20, p.102]. These open data are provided or utilized through an open data platform, which serves as a data archive, data repository, or data infrastructure. A data repository or a data infrastructure can provide direct benefits, such as creating new research opportunities, re-purposing and reuse of data, increasing research productivity, scholarly communication/access to data, stimulating new network/collaborations, and knowledge transfer to industry, thus increasing economic productivity and growth [21]. In addition, a data repository or a data infrastructure also gives indirect benefits, such as reducing re-creation/duplication of data, reducing loss of future research opportunities, lower future preservation costs, re-purposing data for new audiences, and re-purposing methodologies [21]. Therefore, open data are ultimately utilized to create the open knowledge bases of a country. These knowledge bases of a country can serve as a foundation of a knowledge-based economy through knowledge-based innovation.

2.2. Knowledge-based economy and global competitiveness: Endogenous growth theory

In the recent global economy, the share of intellectual capital as a way to contribute to economic growth greatly increased as the portion of knowledge-based industries increases. The OECD defined the knowledge-based economy as one that is "directly based on the production, distribution, and use of knowledge and information" [25, p.3]. That is, it is an economy in which knowledge plays an important role as the main engine for economic growth. According to the Asia-Pacific Economic Cooperation (APEC) [1], the knowledge-based economy has the following characteristics: 1) generalized innovation and technological change, 2) support from effective national innovation systems (i.e., networks between public and private sectors are formed and new technologies/methodologies are created and diffused through interactions in the networks), 3) continuous

human resource development (i.e., high quality education and training are continued throughout the entire professional life of each person), and 4) a business environment that supports firms and their innovations based on effective infrastructures from which individuals and businesses can easily access information from all over the world.

Endogenous growth theory emphasizes that economic growth is the outcome of endogeneity [32]. It holds that investments in human resources [16-22], knowledge [16], and innovation [16] are significant contributors to economic growth. The theory also focuses on the knowledge-based economy's positive externalities, which lead to economic development. The theory highlights the accumulation of knowledge as a source of economic growth by emphasizing the economic mechanism or economic system that enables the productive use of accumulated knowledge bases [16-22-30-31].

Nowadays, most countries focus on their resources and capabilities to increase their growth potential for sustainable economic growth and for the improvement of the overall quality of peoples' lives. In particular, they have recognized the innovation and growth of knowledge-based industries based on intellectual capital as the important engine for driving the continued growth of the future society. Therefore, countries strive for creating, accumulating, and diffusing the key growth factors related to knowledge-based industries. The growth of the knowledge-based industry brings the development and accumulation of the intellectual capital of the country, which leads to further qualitative growth of the national economy. Therefore, the differences in the accumulated intellectual capital across countries can be directly associated with the differences in the upcoming national capabilities and competitiveness.

3. Research Model and Hypotheses

Based on the discussion on the nature of data openness at the government level, the research model and hypotheses of this study are illustrated in Fig. 1.

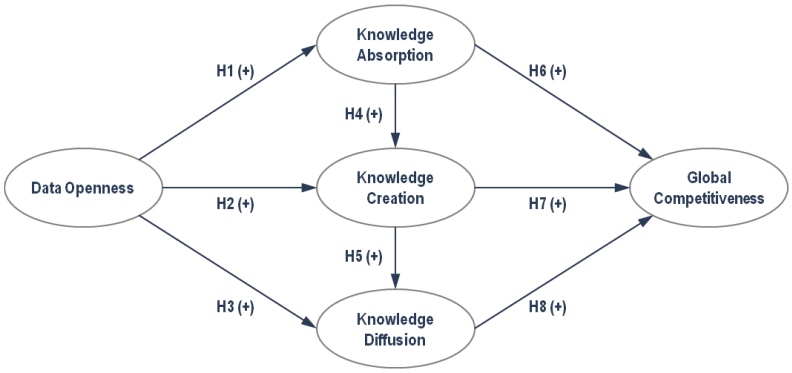

Fig. 1. Research model

3.1. Data openness and knowledge absorption, creation, and diffusion

Phelps et al. [27] identified three types of knowledge-related outcomes, namely, knowledge creation, knowledge transfer, and knowledge adoption. Knowledge creation is the generation of new knowledge, such as ideas, practices, research, products, and services. Knowledge transfer refers to a receiver's efforts to share knowledge with a receiver and the receiver's efforts to acquire and absorb it. Knowledge adoption is the ability to use and implement a discrete element of knowledge, such as products and practices. According to Lundvall [23], knowledge absorption is the first necessary condition for the effective production, diffusion, and

exploitation of economically useful knowledge in the national systems of innovation. Therefore, we expect that government data openness can be realized through the absorption of the existing knowledge for various purposes [21-36]. Furthermore, government data openness can increase the chances of generating new knowledge using the accumulated knowledge [4-21], and then distribute knowledge through an open data platform. Thus, we hypothesize the following:

H1: Data openness is positively associated with knowledge absorption.

H2: Data openness is positively associated with knowledge creation.

H3: Data openness is positively associated with knowledge diffusion.

According to endogenous growth theory, labor in production activities is classified into two types: unskilled labor and skilled labor. Skilled labor can be more productive by leveraging the knowledge accumulated in the process of producing goods. It also can create new knowledge through experience and learning in the production process [22]. In other words, new knowledge is largely dependent on prior knowledge. The newly created knowledge through these processes is again added to another new knowledge creation process. Therefore, knowledge should be considered as a strong economic externality or property of self-reinforcement. The more knowledge we accumulate and utilize, the easier new knowledge/information we can acquire and create. Thus, we hypothesize the following:

H4: Knowledge absorption is positively associated with knowledge creation.

Endogenous growth theory insists that knowledge as a production factor has different characteristics compared with capital or labor as a production material. Knowledge as public goods, such as scientific discoveries and mathematical formula, does not give any obstacles for use. Therefore, knowledge has the characteristic of non-rivalry [31]. Unlike capital or labor, the law of diminishing returns, which means a reduction in the additional production depending on one unit inputs of production factors, is not applied because of the characteristic of knowledge [30-31]. In addition, the accumulation of knowledge as a factor of production does not have a restriction. Therefore, the accumulation/creation of new knowledge (e.g., education and training of the employees, R&D investments) enables continuous product and service development through the spread of such knowledge (e.g., new patent applications). Thus, we hypothesize the following:

H5: Knowledge creation is positively associated with knowledge diffusion.

3.2. Knowledge-based innovation of a country and global competitiveness

In a dynamic changing environment, the competitive advantage of most organizations is based on the enhancement of the capability of knowledge development [3]. Carneiro [3] argued the importance of knowledge development and management to achieve competitiveness. Thus, to acquire the capability to increase competitiveness, the evolution of knowledge through knowledge management should be combined with innovation efforts, updated information technologies, and knowledge development [3]. In particular, knowledge and information technologies are important factors that bring about important changes in the economy of a country [15]. Therefore, in the knowledge-based economy, increasing the value-added goods and services is possible by leveraging the accumulated knowledge to reflect the characteristics of the information society to the fullest. Thus, we hypothesize the following:

H6: Knowledge absorption is positively associated with global competitiveness.

Adopting new ideas and methods in production can lead to the quantitative and qualitative leap of an organization. Therefore, generating new knowledge is possible through an ongoing network operation in cooperation with a company, the government, and the academia to exchange the flow of knowledge. It can act as a crucial factor in strategic management and economic growth [17]. Thus, we hypothesize the following:

H7: Knowledge creation is positively associated with global competitiveness.

Diffusion of knowledge through formal and informal networks is an indispensable process to increase the efficiency of an organization. For this purpose, learning information technologies is necessary. In the knowledge-based economy, knowledge exchange between producers and users is important. The distribution and utilization of knowledge through knowledge networks are as important as the creation of knowledge [17]. David and Foray [8] stressed that an efficient system of access to distribute knowledge is an essential condition for increasing the amount of innovative opportunities. Therefore, they emphasized the importance of knowledge distribution. Dayasindhu [11] found that knowledge transfer is one of the key determinants of industry clusters that lead to global competitiveness. Thus, we hypothesize the following:

H8: Knowledge diffusion is positively associated with global competitiveness.

4. Research Methodology

4.1. Measurements

In this study, we derived the following five constructs from the relevant literature on open data and knowledge-based economy: data openness, knowledge absorption, knowledge creation, knowledge diffusion, and global competitiveness. *Data openness* is defined as the extent to which the government discloses government data. *Knowledge absorption* is the extent to which a country acquires knowledge. *Knowledge creation* is the extent to which a country generates new knowledge. *Knowledge diffusion* is the extent to which a country distributes its knowledge to other countries. *Global competitiveness* is the extent to which a country has competitive advantages. We used the Global Competitiveness Index score of the report announced by the World Economic Forum. The remaining four constructs are composed of formative indicators, and their detailed measurements are described in Appendix A.

4.2. Data collection

In this study, secondary data were collected from three global reports: ‘Open Data Barometer Global Report – Second Edition (ODB)’ [10], ‘The Global Innovation Index 2015 (GII)’ [14], and ‘The Global Competitiveness Report 2014–2015 (GCI)’ [33]. The target year of the reports was 2014. Each research was performed on 86 countries in ODB, 141 countries in GII, and 144 countries in GCI. Based on the list of 86 countries targeted by the ODB, the four countries were excluded from the data that could not be obtained from GII and CGI. Collected data from total 82 countries were used for analysis. Table 1 summarizes the regional distributions of the 82 countries.

Table 1. Regional distributions of the country

Region	Frequency	Percent
East Asia and Pacific	12	14.63%
Europe and Central Asia	25	30.49%
Latin America and Caribbean	10	12.20%
Middle East and North Africa	10	12.20%
North America	2	2.44%
South Asia	4	4.88%
Sub-Saharan Africa	19	23.17%
Total	82	100.00%

5. Data Analysis and Results

A two-stage structural equation modeling approach was applied to validate the proposed hypotheses. The measurement model was first examined to ensure the validity of the measurements, and then the structural relationships among latent variables in the proposed model were tested.

5.1. Measurement model

We used Smart PLS 2.0.M3 to test the measurement and structural models because this method is less sensitive to a small sample size and has greater statistical power than the covariance-based analysis tools, such as LISREL and AMOS. In addition, as the research model of the study has four formative constructs (i.e., data openness, knowledge absorption, knowledge creation, and knowledge diffusion), partial least squares (PLS) method was adopted. Confirmatory factor analysis (CFA) was applied to assess construct validity. Table 2 shows the results of the confirmatory factor analysis.

To validate the formative measurement model, four types of validity were assessed: convergent validity, discriminant validity, multicollinearity, and nomological validity of the instrument. For the formative model, the reliability or internal consistency verification is not required because it assumes that the correlation among the measurement items is low [2-19].

First, convergent validity of the scales was verified using outer weights between the formative measurement items and the formative construct. These outer weights should be significant [6-13-29] As shown in Table 2, all outer weights of the formative measurement items were significant. Second, discriminant validity of the measurement items was assessed by comparing cross loadings among the latent constructs. The cross loadings between each measurement item and the targeted latent variable should be greater than the cross loadings of the other latent variables [24-35]. As indicated in Table 2, all measurement items of each latent variable have discriminant validity.

Third, multicollinearity for all measurement items was examined using the variance inflation factor (VIF). According to Diamantopoulos and Siguaw [12], when the VIF is greater than 10, the model built is considered to have a multicollinearity problem. As shown in Table 2, our results indicate acceptable VIF values, which are all under 3.5. Therefore, results of the inter-construct correlations confirm that each construct shares a larger variance with its own measures than with other measurements. These results suggest that the measurement models fit the data well and merit further analysis. Fourth, nomological validity of the scales was verified using relationships between the formative construct and other models' constructs. These relationships should be significant as many prior studies discussed [37]. Consistent with prior literature, most of the relationships in our model show nomological validity as shown in Fig. 2.

Table 2. Results of the confirmatory factor analysis

Latent variable	Item	Outer weights	t-value	Cross loadings					VIF
				1	2	3	4	5	
1. Data openness	DO1	0.267**	2.496	0.822869	0.609203	0.615820	0.460504	0.519847	2.381
	DO2	0.795***	8.630	0.981653	0.649587	0.772114	0.588707	0.659423	3.300
2. Knowledge absorption	KA1	0.676***	6.617	0.534469	0.852832	0.592421	0.631420	0.569152	2.169
	KA2	0.302***	3.610	0.416047	0.499323	0.250155	0.348838	0.329841	3.086
	KA3	0.464***	3.830	0.413790	0.587468	0.489126	0.353909	0.244987	1.475
3. Knowledge creation	KC1	0.443***	5.191	0.652245	0.595155	0.847676	0.662412	0.601017	2.688
	KC2	0.667***	8.264	0.733290	0.658715	0.936032	0.689112	0.696645	3.030
4. Knowledge diffusion	KD1	0.790***	11.698	0.541005	0.607226	0.755406	0.956818	0.668606	2.874
	KD2	0.226***	3.024	0.466518	0.574038	0.443140	0.660854	0.539771	3.597
	KD3	0.175*	1.838	0.331150	0.496154	0.320656	0.540181	0.484093	1.499
5. Global competitiveness	GC	1.000	-	0.662967	0.598051	0.731030	0.735098	1.000000	-

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2. Structural model

In PLS, the predictive and overall model fit of the proposed model is determined by the following criteria [18-34]. First, predictive fit was assessed using R^2. Values of over 0.26 are considered high, those between 0.13 and 0.26 are considered medium, and those between 0.02 and 0.13 are low. All four endogenous variables show values of over 0.26 (knowledge absorption is 0.461, knowledge creation is 0.662, knowledge diffusion is 0.567, and global competitiveness is 0.613). Therefore, the values are sufficiently high for the model to have a minimum level of explanatory power. Second, predictive fit was assessed using redundancy value, which should be over 0. All four endogenous variables have values of over 0 (knowledge absorption is 0.207, knowledge creation is 0.279, knowledge diffusion is 0.286, and global competitiveness is 0.034). Third, overall model fit (i.e., goodness-of-fit) was assessed using the calculated value through the following steps: 1) calculate the average of R^2 of all endogenous variables (0.576), 2) calculate the average of all communalities of latent variables (0.721), 3) multiply the value from step 1 (0.576) and step 2 (0.721), and 4) calculate the square root of the value from step 3. Values over 0.36 are considered high, those between 0.25 and 0.36 are considered medium, and those between 0.10 and 0.25 are low. As presented in Table 3, our model has high overall model fit (0.644).

Table 3. Research model fit

Latent variable	R^2	Redundancy	Communality
Data openness	-	-	0.820378
Knowledge absorption	0.461021	0.207278	0.440588
Knowledge creation	0.662205	0.279668	0.797356
Knowledge diffusion	0.567343	0.286334	0.548007
Global competitiveness	0.613447	0.034099	1.000000
Average	0.576004	0.201845	0.721266
Overall fit	0.644556		

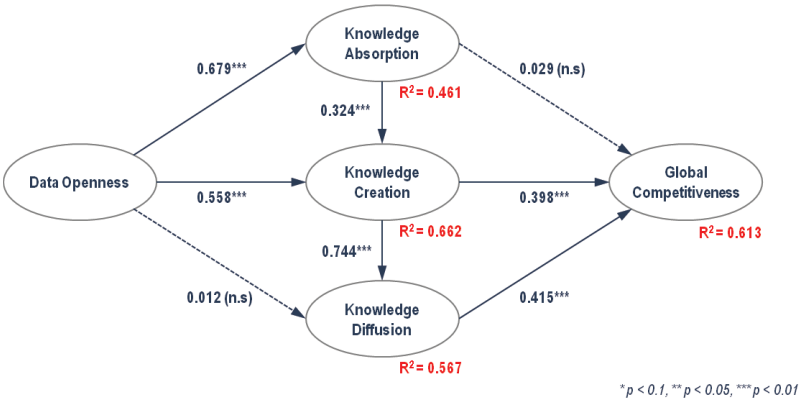

Fig. 2. Analysis result

The structural model reflecting the causal relationships among the constructs was tested using data collected from the validated measurements. As illustrated in Fig. 2, the effects of data openness on knowledge absorption and knowledge creation are statistically significant; thus H1 and H2 are supported. The effect of knowledge absorption on knowledge creation is also significant, thus supporting H4. The effect of knowledge creation on knowledge diffusion is statistically significant, which supports H5. Data openness explains 46.1% of the variance in knowledge absorption, and data openness and knowledge absorption together explain 66.2% of the

variance in knowledge creation of a country. Knowledge creation explains 56.7% of the variance in knowledge diffusion of a country. The effects of knowledge creation and knowledge diffusion on global competitiveness are significant, providing support for H7 and H8. Knowledge creation and knowledge diffusion together explain 61.3% of the variance in global competitiveness of a country.

Contrary to our expectation, data openness is not significantly related to knowledge diffusion, indicating the lack of support for H3. This result can be interpreted as data openness indirectly affecting knowledge diffusion. Data openness can provide opportunities for users to obtain free access to government data and stimulate them to create networks or collaborations for new research/product/service development. However, knowledge diffusion can be realized only through absorbed or created knowledge from the networks or collaborations. In addition, knowledge absorption is not significant. Thus, H6 is not supported. This result indicates that knowledge can have power in global competitiveness when absorbed knowledge creates new knowledge and this knowledge is diffused properly.

6. Discussion and Implications

6.1. Summary of findings

The results of this study can be interpreted from three perspectives. First, government data openness may positively affect the formation of knowledge bases in a country. Specifically, data openness is positively associated with knowledge absorption. The overall amount of information can increase when a government provides accessible data continuously online. Therefore, the amount of absorbed knowledge through these processes can be increased. The analysis result also indicates that data openness is positively related to knowledge creation. The chances for various research and collaborations can be made depending on the increased opportunities to access government data online. Increased research and collaborations may lead to opportunities for the creation of new knowledge. Second, the level of knowledge base of a country may positively affect the global competitiveness of a country. The absorbed and accumulated knowledge generates new knowledge, which has positive effects on the diffusion of knowledge. These positive effects may be due to the characteristics of knowledge as public goods to which the law of diminishing returns is not applied. Finally, data openness ultimately affects the competitiveness of a country through the formation of knowledge bases. Our results show that data openness does not have a direct effect on knowledge diffusion. Moreover, knowledge absorption does not directly affect the competitiveness of a country. Data openness itself serves as an enabler for absorbing any knowledge and forming new knowledge. However, knowledge diffusion is achieved through the interaction between absorption of knowledge and creation of new knowledge. In other words, knowledge absorption plays a role in forming a new knowledge base, but it does not affect the competitiveness of a country. New knowledge creation and diffusion of knowledge positively affect the competitiveness of a country.

6.2. Theoretical and practical contributions

This study has theoretical contributions as knowledge-based research can be applied at the government level. Knowledge related studies are usually conducted at the firm or individual level. In this sense, our study can extend the range of knowledge related research. Moreover, this study is one of the earliest attempts to theoretically conceptualize the concept of data openness at the government level and to empirically validate its effect on global competitiveness from the endogenous growth theory perspective.

This study also provides practical guidance to governments. First, the analysis result of this study shows that government data openness positively affects the formation of knowledge bases and the competitiveness of a country. Therefore, the government of a country is required to provide a variety of ways to access open

government data online (e.g., provision of various use cases and multiple channels to access the data). In addition, it is required to provide opportunities to create various new idea and knowledge to improve the competitiveness of the country by fostering knowledge industries. Furthermore, from the enterprise perspective, it can take advantage of open data as resources for new product and service development. Developing a variety of products, services, and contents by utilizing open data is an effective way to increase profits and gain competitive advantages (e.g., participation in open data contests to receive funds and create a professional network).

7. Conclusions

On the basis of the analysis of the data of 82 countries, we found that government data openness could positively affect the formation of knowledge base in a country. The level of knowledge base of a country may positively affect the global competitiveness of a country. The limitations of this study as follows. First, we used secondary data in the data analysis at the government level. If possible, primary data designed for the research purposes should be used to confirm and extend the findings of this study. Second, data from 82 countries were used in this study. Thus, these results may have to be carefully interpreted, and replications of this study with more country data are encouraged. The effect of government data openness can be explored through a variety of perspectives in various fields, such as politics, economy, society and technology. In this sense, this study provides a starting point to conduct future open data research at the government level.

Acknowledgements

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Appendix A. Measurements

Constructs	Measurements	Data sources
Data openness	OD1. Is the data available online from government in any form?	ODB, 2015
	OD2. Is the publication of the dataset sustainable?	
Knowledge absorption	KA1. Royalties and license fees payments (% of total trade)	GII, 2015 (5.3.1)
	KA2. High-tech net imports (% of total trade)	GII, 2015 (5.3.2)
	KA3. Communication, computers and information services imports (% of total trade)	GII, 2015 (5.3.3)
Knowledge creation	KC1. Number of published scientific and technical journal articles (per billion PPP$ GDP)	GII, 2015 (6.1.4)
	KC2. Number of published articles that received at least H citations (index) in the period 1996-2013	GII, 2015 (6.1.5)
Knowledge diffusion	KD1. Number of international patent applications filed by residents in the Patent Cooperation Treaty (per billion PPP$ GDP)	GII, 2015 (6.1.2)
	KD2. High-tech net exports (% of total trade)	GII, 2015 (6.3.2)
	KD3. Foreign direct investment net outflows (% of GDP)	GII, 2015 (6.3.4)
Global competitiveness	GC. Global competitiveness index score	GCI, 2014